Menlo Park Notebook #165 [N-81-00-01]

This notebook is undated but was probably used in 1880. The entries are by Francis Upton and William J. Hammer. Included are notes, calculations, and tables relating to conductors needed for the Pearl Street central station. There are also a few drawings of electric power distribution systems. The label on the front cover is marked "Hammer," "Upton," and "Line Figureing for Station." The book contains 284 numbered pages.

Blank pages not filmed: 234-283.

LIBRARY OF THE

BOARD OF PATENT CONTROL,

120 BROADWAY, NEW YORK.

From Library
GENERAL ELECTRIC
44 Broad St. N.Y.
May 1, 1896

Square No. 1

2/270 Lights Blocks
135

2/1199
599 600 feet

.0049
135
.3245
.147
49
.6615

11.2
135
560
336
112
1512.0

1530 ft

13/270
27 Lights

.0124
.27
868
248
.3348
cross section

145
27
1015
290
3915 weight

1320

14/270
27 Lights

3610.00

.0106
27
742
212
.2862
c.a.

10819
27
75733
21638
292032 weight

2

1092 — 2 | 333 Lights / 166.5 — 546.

.0044 × 166.5 = 220 + 264 + 264 + 44 = .7326

911 × 166.5 = 5555 + 4555 + 911 = 151 6.8 15

3

1141 — 2 | 306 Lights / 150 — 670

.0045 × 150 = .6750

9.8 × 150 = 1470 lbs

1841 + — 10 | 333 / 33.3

.0108 × 33.3 = 324 + 324 + 324 = .3596 4

112.2 × 33.3 = 3366 + 3366 + 3366 = 3738.26

1170 + — 10 | 300 Lights. / 30

.0094 × 30 = .2820

85.6 × 30 = 2568.0

1204.2 — 10 | 333 / 33.3

.0097 × 33.3 = 291 + 291 + 291 = .2230 1

90 × 33.3 = 2997.0

7030 — 18 | 300 / 30 Lights.

.0083 × 30 = .2490

66 × 30 = 1980

(1490 / 545)

2 | 340 / 17

.0044 × 770 = 3380 + 44 = .1780

9.11 × 770 = 6370 + 911 = 1543.70 lbs.

1000 ÷ 1 | 345 / 34 Lights

.0081 × 34 = .2754

62.5 × 34 = 250.0 + 1875 = 2125.0

920 ÷ 10 | 340 / 34

.0074 × 34 = 296 + 222 = .2516

52.9 × 34 = 2116 + 1587 = 1798.6

(1266 / 633)

(400 / 200 Lights) Figure 5

.0052 × 200 = 1.0400

12.18 × 200 = 2436.0

860 ÷ 10 | 400 / 40

.0069 × 40 = .2760

46.2 × 40 = 1848.0

990 ÷ 10 | 400 / 40

.0080 × 40 = .0320

61.5 × 40 = 2460.0

1967
493 feet

2/250 Lights
125

125.
.0041
125
500
.5125

125.
7.81
125
625
875
976.25 ft

2/894
447 feet

2/160 Lights
80.

.0036 11 sq. in.
80
0.2880

6.050 sq. in.
80
484000

1050 +

10/250
25

.0045
25
150
2125

68.9
25
3445
1378
1722.5

1210 –

10/250
25

.0070
25
.1750

47.0
25
235.5
946
1182.5

740 +

10/160
16

.0060
16
.0960

34.2
16
205 2
342
547 sq in

690 –

10/160
16

.0056
16
10896

29.7
16
1782
297
475.2

2 // 127
513.5

2 | 220 Lights
110

.0042
110
.0042 0

8.45
110
929.50

1500 +

10 | 220
22 Lights

.0121
22
242
242
.2662

141.6
22
2812
2812
3 1 1 9 2.

1210 –

10 | 1210
22 Lights

.0098
22
196
196
.2156

91.5
22
1830
1830
2013.0

2 // 238
619

2 | 460 Lights
230

.00500
230
1500
100
1.15500

120
230
27600

1250. +

10 | 460
46 Lights

.0101
46
4646
4646

47.6
46
2856
1904
2189.6

1410 –

10 | 460
46 Lights

.0114
46
6844
4560
.52440

124.2
46
7452
4968
5713.2

2 | 230
115 Lights

2 | 1059
529.5

.0042 × 115 = 210 + 42 + 42 = .4830

8.45 × 115 = 4225 + 845 = 971.75

1450 ÷ 1230
23

.012 × 23 = .276 + .036 = .2714

132.2 × 23 = 3966 + 264.4 = 2063.6

1320 ÷ 1230
23

.0131 × 23 = .393 + .262 = .3013

164 × 23 = 492 + 328 = 3772

2 | 11402
708

.00857 × 185 = .0285 + .456 + .057 = 1.05743

15.3 × 185 = 765 + 1224 + 153 = 2830.5

1190 ÷ 10 | 370
37 Lights

.0096 × 37 = .3552

28.4 × 37 = 618 + 2652 = 3270.8

1090 ÷ 10 | 370 Lights
37

.0088 × 37 = .676 + .254 = .9156

742 × 37 = 5194 + 2226 = 27454

12

2)360 Lights
180

2)252
641

.0052
180
41160
52
.9360

12.8
180
10240
128
2304.0

9.36 .0079 36
36
.2844

5.36
21.60

840 .0068 32
32
.2176

44
32
43

420 .0037 32
32
.1088

48.44
36
2701
1452
174.24

13

2)320 Lights
160

2)1283
641.5
320
961

.0052
160
3120
52
.8320

12.8
160
7680
128
1048.0

2 150 Lights
25

2/452
226.

.0018
25
90
36
.04500

8.025
25
13 123
6050
75.625

6284

10/150
5

1.50
5
10.250

24.10
5
120.

495 -

10/150
5

.0051
5
.0255

24.8
5
124.0

2/1320 Lights
160

2/924
462

.0037
160
02220
37
.5920

6.612
160
096720
6612
105.7920

490+

10/1920
92

.0039
92
.75
117
.1248

15
92
1380.

2890 -

10/1920
92

.0018
92
.1656

2906
92
6812
2718
105.792

2|110 Lights
55

2|760
380

.0031
55
155
155
.1705

4.512
55
22560
22560
248.160

500 ×

10|110
11 Lights

.0040
11
.0440

15.6
11
172.6

270

10|110
11

.0022
11
.0232

4.55
11
60.05

2|280
140 Lights

2|1247
623.5

.00560
.7000

12.0
140
16800

650 ×

10|280
28

.0052
28
.1456

26.4
28
2112
528
739.2

430

10|280
28 Lights

.0033
28
.0900

1655
28
9243
2310
323.40

2 | 180 Lights
40

2 | 188
.394

.003 | 40
.1240

4.512
40
180.480

880 +

.0065
1952

41
40
920

920 -

.074
6

529
6
42 92

.059 2

2 | 210 Lights
105

2 | 867
433.5

.0036
105
.0180
36
.3780

6.05-0
105
3025-0
605-0
635.25-0

9607

10 | 210
21

.0074
.1638

57.6
21
576
115-2
1209.6

1070-

10 | 210
21

.0086
21
86
172
1806

71.1
21
711
1422
1493.1

2 | 220 Lights
110

2 | 1041
520.5

.0042
110
.4620

8.45
110
929.50

1120 +

.0042
26
.1092

7.84
26
156
78
1716

1225 -

10 | 220
22

.0024
26
.0624

94.6
26
1892
1892
2081.6

2 | 260 Lights
130

2 | 1030
515

.0042
130
1260
42
.5460

8.45
130
2535.0
845
1098.50

220 +

10 | 260
26

.0023
26
.0598

5.25
26
315.0
105.0
136.50

300 -

10 | 260
26

.0024
26
.0624

5.6
26
1456

2 | 140 Lights
70

2 | 951
475.5

.0039 × 70 = .2730

7.2 × 70 = 504.0

10 | 140
14

2 | 1175
587.5

2 | 260 Lights
130

.00047 × 130 = .1410 + 47 = .6110

10.5 × 130 = 315.0 + 1050 = 1365.0

180 +

.0014 × 26 = .0364

2.025 × 26 = 1215.0 + 4050 = 4265.0

560 −

.00045 × 26 = .1170

19.6 × 26 = 1176 + 392 = 509.6

2/200 lights
150

2/1129
564.5

.0045
150
.675

9.8
150
1470.0

2/45
2.25

2/1413
706.5

.0057
225
285
114
1282.5

15.3
225
765
306
3442.5

.0075
45
375
300
33.75

54
45
2430.

1410

.0100
45
450

96.1
45
4805
3847
4324.5

1/300
30

1413
30
14190

2/290 lights.
145

2/1054
527

.0042 × 145 = 210, 168, 42 → .6090

8.445 × 145 = 42225, 33780, 8445 → 1225.25

200 + 10/290 = 29

10/290 = 29

$80 − 10/290 = 29

9.5 × 29 = 855, 190 → 275.5

2/210 lights.
105

2/880
440

.0086 × 105 = 205, 41 → .4305

60.50 × 105 = 3025, 6050 → 6352.50

~~8442~~ 103 = 39 8 6 0 → 820.260

520 + 10/210 = 21

.0042 × 21 = .0882

10/210 = 21

690 − 10/210 = 21

.0056 × 21 = .1176

29.7 × 21 = 297, 594 → 623.7

2 | 260
130 Lights

2 | 1039
519.5

.0042
130.
1260
42
.5460

8.45
130
2535 0
845
1098.50

)3604 .1[illegible]
26.
.257
216
1112
43.05
26
2581 30
8
1119,31

1520 10|240
26

.049[illegible]

6[illegible]
26
3712
1964
1676.2

2 | 712
356

2 | 155
77.5 Lights.

.0029
77.5
145
203
203
.2.2475

405
77.5
2025
2835
2835
3138.75

1250 10|100
12.5

.0083
12.5
415
415
83
.1037.5

880 10|2075
187.5

.0671
1535
935
935
71
.11005

75 0.20

2/320 lights
160

2/896
448

.0036 × 160 = .57.60

6.05 × 160 = 968.00

2/1160
80 Lights

2/690
345

.0028 × 80 = .2240

3.612 × 80 = 288.960

550 +

10/160
16

.0047 × 16 = .0752

21.0 × 16 = 336.0

500 −

10/160
16

.0040 × 16 = .0640

196 + 156 = 279.6

32

2/160 Lights.
80

2/923
461.5

.0037 × 80 = .2960

6.612 × 80 = 528.960

4704

.0036 × 16 = .0576

13.8 × 16 = 82.8

1104

.0027 × 16 = .0432

12.1 × 16 = 193.6

33

2/150 Lights.
75

2/849
424.5

.0034 × 75 = .2550

5.512 × 75 = 275.60 + 38584 = 413400

3604

.0027 × 75 = .2025

8.1 × 75 = 405 + 81 = 1215

610 –

.0049 × 15 = .0735

23.2 × 15 = 116.0 + 232 = 348.0

15 Lights.

2/830
415

2/150
75 Lights.

.0034
75
.2550

57.52
75
27560
38584
418.400

710 -

10/150

920 -

.15 Lights

2/240
120 Lights.

2/1033
516.5

.0042
120
.5040

8.42
120
1014.00

760 -

.0078
24
3112
1560
.1872

57.4
24
2296
1148
1378.4

1280 -

24 Lights.

.3133
24
12532
6266
7519.2

2/734
867

2/150
90 lights

.0029 × 90 = .2610
405 × 90 = 364.50

1461
230.5

2/90
45 lights

.0019 × 45 = .0955
1.800 × 45 = 81.000

2/160
80

2/617
308.5

.0024
80
.1920

.2812
80
224.960

1220 ÷

16.165
16 2.7

.129

65.1
16
2.9 C
144
141.6

1220 ÷

16

16
.1136

2904
934
1774

2/90
45

2/519
259.5

.0021
45
.0945

2.112
45
10560
8448
95040

320 ÷

10/90
9

.0084
9
.7604

42.
9
378

640. —

9 2.56

.00502
9.
.02268

.2506
9
2.257

2/765-
382.5

2/90 Lights-
45-

.0031
45-
.1395-

4.572
45-
22560
18048
203,040

2/780
390

2/150 Lights.
75-

.0031
75-
.2325-

4.512
75-
22560
31584
338,400

2/120 Lights
60

2/710
353

.0029 60 .1740

4.050 60 243.000

2/921
460.5

2/180 Lights
90

.0037 90 .3330

6.612 90 595.08.0

2/564.
432.

2/220
110 Lights

.0036 × 110 = .3960

6.050 × 110 = 665.500

2/592
296

2/90 Lights
45

.0024 × 45 = .1080

2.812 × 45 = 14060 + 11248 = 126.540

2/727
363.5-

2/120
60 Lights

.0029 × 60 = .1740
4.050 × 60 = 243.000

12 Lights.

.0161 × 12 = .1932
794 × 12 = 11532

12 Lights.

.1 × 12 = 1.2
.911.8

2/595
297.5-

2/80
40 Lights.

.0024 × 40 = .0960
2.812 × 40 = 112.480

.0084 × 8 = .0672
671 × 8 = 5408

992-

8 Lights

.0080 × 8 = .0640
61.5 × 8 = 492.0

2/230 — 125 lights

2/876
431

.0036	6.050
125	125
180	30250
72	12100
36	60 50
.45000	756.250

1150 — 230 lights.

225 — 235

.0074	
25	
370	
148	
.1850	12 12.7

2/200 — 100 lights

2/797
398.5

.0032	5.
100	100
.32000	500.

1144 — 20 lights

.0584	67.5
20	
.1680	1352.0

2/872
436

2/150
75

.0036
75
.2700

6.0378
75
30250
42350
453.750

1180 +

.0075
15
.1125

87
15
1305

1370 –

15 Rings.

.0111
15
.1665

1173
15
5865
1173
17595

2/911
450.5

2/140
70

.0037
70
.2590

6.612
70
462.840

1440 +

.0116
17
4647
116
.16241

1200
12
2400
1824
12576
14424

1690 –

14 Rings.

.0137
14
5548
137
.1918

1702.5
14
7210
1785
24795

320 · 320 Wires

Dead Block	No of Lamps	Amperage Divided by Cross section of Solid Wire	Cross section of Solid Wire	Weight of Solid Wire	Length of Solid Wire	Cross section of Stranded Wire	Weight of Stranded Wire	Length of Stranded Wire		
1	270	1199	.6613	5612.	1530.	.3338	3015.	1320.	.2586	2790.3
2	333	1092	.7326	5168.	1340.	.3596	3236.	1200.	.2230	2409.6
3	380	1143	.6750	1478.	1170.	.2620	2568.	1030.	.2496	1880.
4	340	1090	.7480	1548.7	1060.	.2754	2125.	920.	.2516	1798.4
5	400	1266	1.040	2566.0	860.	.2760	1748.	990.	.1820	2460.
6	250	981	.5125	976.25	1050.	.2125	1722.5	1870.	.1750	1185.25
7	160	894	.2880	484.0	740.	.0960	547.2	690.	.0896	415.2
8	220	1027	.4420	923.5	1500.	.2662	3093.2	1210.	.2156	2013.
9	460	1238	1.150	2760.	1250.	.4646	4389.6	1410.	.5244	4713.4
10	230	1059	.4830	971.75	1460.	.2714	2063.4	1620.	.3013	3772
11	370	1400	1.0544	2830.5	1190.	.3552	3279.8	1090.	.3156	2795.4
12	360	1284	.9360	2304	980.	.2454	2160.	880.	.2556	1742.4
13	320	1283	.8320	1048.	840.	.2176	1405.	420.	.1088	352.8
14	50	452	.0450	75.6	420.	.0250	120.	630	.0255	126
13	4083		13.1331	28844.6	15539.0	3.7179	33.7185	15234.2	3.0622	24294.8

2640.0

55

No. of Block	No. of Lamps	Energy per Lamp per Hour	Cross Section of Duct	Weight per Foot	Length of Main	Cross Section of Main	Weight per Foot	Length of Main	Cross Section of Main	Weight per Foot	Length of Main	Cross Section of Main	Weight per Foot	
15	320	924	.8720	1057.92	480	.1248	188.0	230.	.0578	105.92				
16	110	760	.1705	248.16	500	.0440	172.6	270.	.0732	60.03				
17	280	1247	.7050	1680.	650	.1456	737.2	430.	.0990	323.4				
18	80	788	.1240	180.48	800	.0520	320.	920.	.0572	336.				
19	210	967	.3750	635.25	960	.1638	1209.6	1070.	.1806	1492.1				
20	220	1041	.4620	923.50	1120	.1980	1724.8	1230.	.2156	2061.2				
21	260	1130	.5466	1078.5	290	.0598	1365.	300.	.0724	1456.				
22	140	951	.2730	584.			V							Residential Lateral Block
23	260	1175	.6110	1365.	180	.0364	426.5	560.	.1170	509.6				
24	360	1129	.6750	1470.	620	.1500	720.	870.	.2100	1419.				
25	450	1413	.12825	3442.5	930	.3375	2430.	1240	.4500	4324.5				
26	290	1054	.6090	1225.25	200	.0464	725.0	890	.0568	278.5				
27	210	880	.4300	635.25	520	.1082	354.6	690.	.1176	623.7				
273	3130		6.6335	1457.91	9260	1.1465	9810.2	8700.	1.6348	1159.442				

No of Blocks	No of Trains	Length of Drawbar	Cross Section of Draw Bar	Weight of Draw Bar	Length of 1 main Wire	Cross Section of 1 main Wire	Weight of 1 main Wire	Length of 2 main Wire	Cross Section of 2 main Wire	Weight of 2 main Wire	
28	260	1039	5466	10985	830.	.1742	1119.3	1020	2132	16852	
29	155	712	2475	3138	1050.	.1375	1067.75	880	1100.5	7502	
30	320	896	576	96.80	860.	.2208	1478.4	640	.1664	8192	
31	160	696	224	258.96	580.	.0752	336.	500	.0640	2496	393.5
32	160	923	2960	528.96	470.	.0608	.2208	440	.0560	1936	521.9
33	150	849	2558	413.40	860.	.0435	121.5	610	.0735	3485	1210.6
34	150	830	2558	413.40	710.	.0855	472.5	920	.1110	7935	
35	240	1033	5049	1014.	960.	.1872	1382.4	1280	.2472	24576	
36	180	734	2610	364.5	1310.	.1908	1935.0	1120	.1620	14112	
37	90	461	0855	81.	1150.	.0801	680.4	1040	.0756	6084	
38	160	617	1920	224.96	1020.	.1296	1044.6	880	.1136	7744	
39	90	519.	0945	95.04	820.	.0604	378.	640	.0468	2304	
402	2115		35227.5	4938.295	10076.	14396.85	28335.5	9970.	13857.5	109313	

No of Block	No of Turns	Height of Disk 1 inch	Cross section Disk 1 inch	Weight of Wire	Diff. of Disk 1 inch	Height of 1" main Wire	Cross Section of 1" main Wire	Weight of 1" main Wire	Length of 1" main Wire	Cross Section of 1 main Wire	Weight of 1 main Wire	
40	90	765	.1895	283.64	720	.0522	291.6	550	.0396	170.1		
41	150	780	.2325	338.4	570	.0690	304.5	790	.0960	5-85.5		
42	120	710	.1740	243.	960	.0936	691.2	1070	.1032	855.2		110078 Lamps
43	180	921	.3330	375.28	1130	.1638	1434.6	1430	.2070	2291.4		Cross section of Disk wire
44	220	864	.3960	665.5	1530	.2928	3212	1348	.2376	2466.4		29.12270
45	90	592	.1080	126.54	1320	.0756	980.1	1260	.0918	892.8		Length of Disk wire
46	120	727	.1740	243.	1248	.1200	1153.3	1120	.1080	990.8		48950.005
47	150	595	.0960	112.48	1040	.0672	540.8	990	.0640	492.0		Length of 1" main wire
48	230	876	.4500	726.25	1100	.2064	1798.8	920	.1702	1211.7		7585.0
49	200	797	.3200	500.	790	.1250	780.	1040	.1040	1352		Cross section of 1 main wire
50	150	872	.2700	453.75	1180	.1425	1305	1370	.1665	1757.5		75287.21
51	140	911	.2520	462.84	1440	.1624	1814.4	1680	.1918	2499		Length of 1 main wire
51	1778		2952.0	6267.88	13020	15736	17362.2	13570	1643	15528.9		47024.2
						Ohms						Ohms 1.66976
												6336.394

Total no of Lamps — .11078.

Length of Distributing Wires — —

Cross Section of ⅛" " — 29.12275

Weight of ⅛" " — 48950.005

Length of "+" main Wires — 45880.

Cross Section of "+" main Wires — 8.18609

Weight of "+" main Wires — 75287.21

Length of "−" main Wires — 47024.2

Cross Section of "−" main Wires — 7.66976

Weight of "−" main Wires. 66363.842

75.
.63
49
187000

64

23
24
47

7326
366

1092
386
1978
20
1498

28
13
41

49 35
28 28
77 63

1141
399
1540

65

Both Sowing Lbs.

1 4199
594
1798

2 | 6615
.3307

D	24	Wires	1798 feet
D7m	47	Wires	410 feet
	44	wires	208 feet
	20	wires	20 feet
2	23	wires	20
	28	"	1498
	41	"	202
	77	"	157
	63	"	157
	35		203
	49		15
	35		15

3 1540

1. Test Cross section No. Wire 67
two Ohm Low Ohm

1798.

2.

3.

214
194
220
176
804

112

.5.25
5
26.25

124
124
1364 Volts

26.25
6.62
180
20960
262
47160

5/124
25
15, Volts

5/124
2.48
1488

For 120 volts to start with 1/5 more volts fall

5/124
2.48
14.88 Volts

30 Lamps at equal distances 66' along a conductor each having 10 Ohms in the conductor will have a fall of E.M.F from 100 to 87.6 Volts
124 Volts
87.6
100 s
The conductor will weigh 440.7 lbs.

10 Lamps will have the same fall and conductor will weigh $\frac{440.7}{3} = 146.9$ lbs.

See page 77

345
198
10
208.

1320
2.05
1112

24 | 370
155
22.5
29
235
4715
10
264
62
87
26
9205
10
137
34.7
139
39.3
1267.5 feet

1267 feet

270 lamps

200 lbs for 10
27
5400 lbs Cu

3915
2940
6855 in summary of ll
5400
1455
1512 in distribution
2967 lbs
1483

6855
1512
270 | 8367 | 30 lbs per lamp
810
67

6,1336
2,7589
2.7589
18 1.2553
2.9067

8.67 lbs
1614
538 lbs

188
386
574 feet

40 for 1a Canal
1
2055
4107
6105 for 1a Canals

43.4 Volts
14 Volts fall
29

1483, 6105 :: 14 :

188
386
574

2.7589
2
5.5178

3.2553
2
6.5106
5.5178
.9928

9.83

440.7 lbs Cu

$1800^2 : \frac{a^2}{574} :: 440.7 : X$

Comp 1800^2 3.4894
log 440.7 2.6442
log a^2 5.5172 6.1336
1,6508 44.7 lbs

Square 1

14.88	1.1726
146.9	2.1670
comp 1800	6.7447
1800	6.7447
	5.6564
	6.8290 − 70
	2.7589
a^2	2.7589
b	1.4314
comp c	6.5280
	.3062

2 Volts

1.1726
1.1346
.0378

6.8290
10378
6.7912

$a = 574$
$b = 120 + 150 = 270$
$c = 2967$

From page 71

Let a = distance furthest lamps is away
& b = no lamps ÷ 10
c = amount of copper at hand
X = fall
d = amount to 10 lamps
E.M.F. by Tables
100 ohms to lamps

$1800^2 : a^2 :: 146.9 : d$

$$\frac{\frac{1488}{c}}{bd} = X$$

$$\frac{14.88\,bd}{c} = X \qquad d = \frac{146.9a^2}{1800^2}$$

$$\frac{14.88 \times 146.9\,b\,a^2}{1800^2\,c} = X$$

13.64 Volts in place 14.88
to represent fall from 110 Volts

78 Square 2

a
293
10
385
20
143
5873

c 190 lamps on one side
1267 feet
19
200
3800 Ibs Cu.

140
200
28000
3500
6600

3736
2997
6733

133
1517
1640

Square 2 79

D 1517
+ 3736
— 2997

333 | 8250 (25 Ibs Cu ft Lamp
666
1584
1332

6.82290
587 2.7686
587 2.7686
19 1.2788
1690 3.7852
.4302
190 7.72128
330 2.57185
.6699

486 6.82290
2.6866
2.6866
1.1461
7.0938

276 .4421
256 .4093
4.66 Volts

Square 3

1470
2568
1980
6018

Saw Camps!

105
30
3150

6018
3150
4868

10
137
20
394

82

From page 76 & 77

13.64 1.1348

5.6564

6.7912

b = 18 2.6566

c = 486 2.6866

c = 806 1.1461

7.0894

6.3992 2.494

Square of

0.7370

2.1670

6.7447

6.7447

6.3934

5.6564 1.

5.456 .7369

6.3933 .0002473

83

.2.5 Volts can be lost in wires leading from main distributing

13.64

2.5

5.456

From page 77

Let y = amount Cur required to cause fall of 2.5 Volts

No. Lamps = b

Furthest lamp a feet away.

$10,10^2 : a^2 :: 146.9 : d$

$3.456 d\ b = y$

$\frac{5.456 \times 146.9\ a^2\ b}{1800^2} = y$

$.0002473\ a^2\ b = y$

10
386
20
188
804 feet = a

b = 15

6.3933 — 10
2.7810
2.7810
1.1761
3.1314 1350 lbs

10
195
20
390
615

b = 12
15

6.3933
2.7889
2.7889
1.0792
3.0563

1120
24.70

10
385 (143
20 71.5
71
√486 6.3933
14 2.6866
2.6866
1.1461.
2.9136

818

10
387
20
72
489 15

6.3933
2.6893
2.6893
1.1761
2.9486

887
1705

Square 3

10
394
20
90
514
140

6.3933
2.7110
2.7110
1.1461
1.9614

916

10
390
20
90
510 120

6.3933
2.7076
2.7076
1.0792
1.8877

773
1689.6

Block 4

395
70
170
20
405
1020
510

6.3933
2.7076
2.7076
1.1461
2.9546

1.8085
901.

1.8085
1.2304
3.0389

1090
1991

Block 5

10
384
20
178
20
400
10.

1022
511

6.3933
2.7084
2.7084 1.8101
16 1.2041
3.0942 1030

1
1.8101
14 1.1464
2.9552 904
1934

Block 6

10
492
20
523

6.3933
2.7185
2.7185
1.3010
20. 3.1313

198
267
465.
5
470
30
500

1350

Block 6 & 7

10
16.2
25
190
387

6.3933
2.5877
2.5877
0.9542
9 2.5229

333
1683

Block 8

10
380
20
119
50
529

6.3933
2.7235
2.7235
1.2788
3.1191

19

1310

Block 9

Both sides

10
376
20
296
20
341
10
1073
√536

150
100
100
370

6.3933
2.7292
2.7292
37. 1.5682
3.4199. 2620

Block 10

Both sides

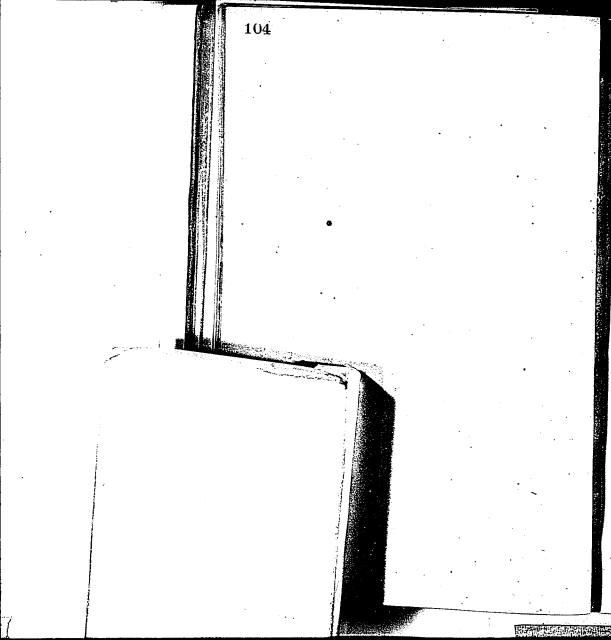
10			
336		6.3933	
20		2.7396	
168		2.7396	
20		1.2553	
308	23	3.1278	1340
20			
193			
10			
1099			
549			

Block 11

20
193
20
487
20
188
10
2938
469

4.0
13.0
4.0
23.0

6.3933
2.6712
2.6712
1.3617
3,1074 1280



Block 12

20
494
10
1524 28
530
1054
527
263

6.3933
2.4200
2.4200
1.4472
2.6805 399

140
20
20
180 4
90

6.3933
1.9542
1.9542
0.6021
.9038 81
480

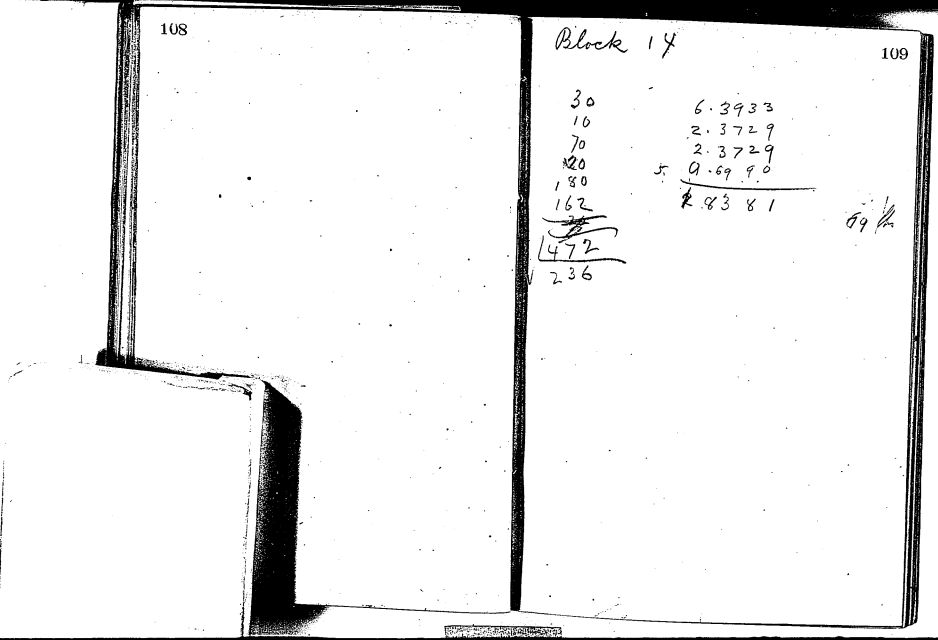
2/399
199
81

Sup Subtracts

498
200
298
17
315

6.3933
2.4983
2.4983
7.21 0.8573
2.2472

175
455



Block 14

30
10
70
120
180
162
472
236

6.3933
2.3729
2.3729
5 0.6990
$83.81

69½

Block 15

29.4
24.3
14.2
286.6
143.3

6.3933
2.1593
2.1593
1
1.7119 54.5

14
264
29
307
153

6.3933
2.1847
2.1847
1
1.7827 61.

60 lamps.
2 wafers

6.3933 20
2.3010
2.3010
0.7782
1.7735 60

134
30
30
194
97 4

6.3933
1.9828
1.9828
0.6021
.9690 9

204.5

Block 16

15
242
30 4
287
143

6.3933
2.1553
2.1553
.6021
1-3560

20

16
10
4

Block 17

30	6.3933	30 lbs
335	2.2945	
30	2.2945	
395	11	
197	19823	96

both sides

30	6.3933	
268	2.5378	
20		
363	2.5378	
10		
691	12.10792	
345	2.5481	353
		479 lbs

Block 18

30
10
25
20
10
438

6.3933
2.6415
2.6415
7 0.8451
2.5214

332
20
352

40
262
20
95
40
457
228

6.3933
2.3579
2.3579
9 0.9542
2063 3

115

150
30
30
20
260
130

6.3933
2.7139
2.1139
4. 6021
1.2239

20

70

205

Square 20

0	
190	6.3933
20	2.5809
320	2.5809
20	1.1161
191	14 2.6712
10	
163	
381	

469

Square 21

10
234
20
142
6

10
224
20
247
20
142
663

.46
26
40
55
135

6.3933
2.8235
2.8235
1.1303
3,1706

1408 lbs.

Square 22

370
20
390
19—

6.3933
2.2900
2.2900
1.0792
2.0525

30

115—
145—

Square 23

108
370
20
275
20
335
10
1048
520

6.3933
2.7160
2.7160
21 4 3222
3.1475

1410

128

34
320
49
407

Square 24

129

24
16
286
20
215
20
370
20
218
1183
541

6.3933
2.7716
2.7716
30 1 4771
X3.4136

25.90

Block 25

10
282
20
428
20
285
110 45
522

6.3933
2.7177
2.7177
301.4771
3.3058

2020

Block 26

10
320
20
204
20
297
10
881
449

6.3933
2.6444
2.6444
1.3802
24 3.0623

1150

Block 27

10
198
20
218
28
202
10
678
33.9

6.3933
2.5302
2.5302
1.1761
13.6298

426

Block 28

10
285
20
168
20
231
10
1864
432

6.3933
2.6355
2.6355
1.3222
2.9865

21.

970

Block 29

10
179
20
.139
20
187
10
564
282

6.3933
2.4502
2.4502
1.1139
24176

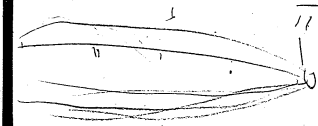
277

Block 30

30
21.3
10
61.3
12.5

6.3935
2.0969
2.0969
10.9031
1.490.2

31.0
5.0
3.5
11.6



Block 31

10
232
20
88
20
246
20
84
20
740
370

6·3933
2·5682
2,5682
1,2041
2·7338

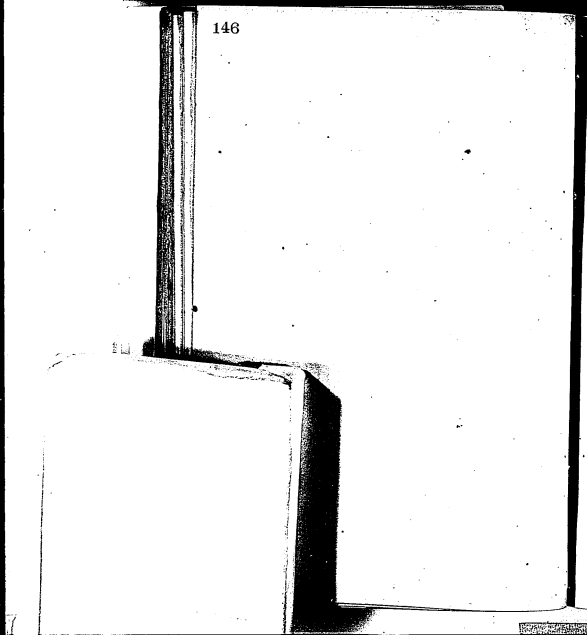
542

Block 32

249
20
240
20
227
20
176
20
972
486

6.3933
2.6866
2.6866
16 1.2041.
2.9706

935



Block 33

10
257
20
97
820
270
20
124
362

6.3933
2.5587
2.5387
12 1.0792
2.5899

390

Block 84

10
193
20
219
20
167
20
211
10
870
435

6.3933
2.6385
2.6385
.14 1.1461
2.8164

6554

Block 35

10
3.10
20
186
20
330
10
1886
443

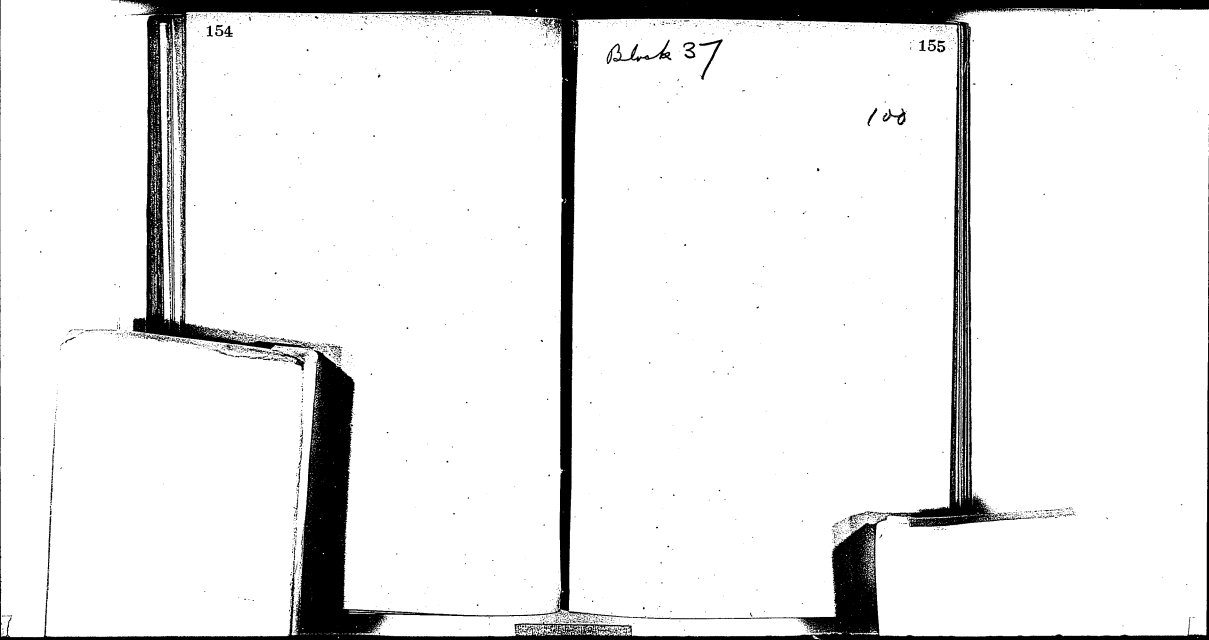
6.3933
2.6464
2.6464
20 1.3010
2.9871 971.

Block 96

10	6.3933	
188	2.4757	
20	2.4757	
158	131.1139	
20	2.4586	287
192		
10		
598		
299		

Block 37

108



Block 38

lav

Block 39

Lots 30

Block 40

10 6.3933
177 2.6053
20 2.6053
196 0.7752
403 6. 2.3821

241

Block 41

10
215
20
159
10
413
205

6.3933
2.3118
2.3118
7 0.8451
1.8620 .

73.

Block 42

10
194
20
141
10
375
187

6.3933
2.2714
2.2718
69.0542
1.6907

~~50~~
60

Block 44

32
10
190
20
214
20
196
20
220
10
936
468

6.3933
2.6702
2.6702
22 1.3424
3.0761 1200

Block 43

10	6.3933
310	2.6464
20	2.6464
186	20 1.3010
30	2.9871
330	
10	
886	
443	

971

Block 35

10	~~2.5798~~
296	2.5977
20	2.5977
148	1.1761
20	.6398
296	2.7648
10	.0664
740	.8312
370	

582 678

Block 45

42
222
20
52
336
168

6.3933
2.2253
2.2253
0.6990
1.5429
4 0.6021
2.1450

20
140
160

Block 46

52	6.3933	50
227	2.6160	
20	2.6160	
114	9 0915 42	
413	2.5795	380
		430

Block 47

52
230
20
43
315

7

6.3933
2.4983
2.4983
0.8451
12.2350

20

172
192

	6.3933	
10	2.6117	
240	2.6119	5-0
20	19 1.2788	
179	2.8955	7-5
409		

Block 49

10
244
20
115
20
250
20
148
10
437
418.

6.3938
2.6212
2.6212
20 1.3010
2.9367

864

Block 5-D

100

Block 51

40
160
20
266
20
186
20
285
60
1981
490

6.3933
2.6902
2.6902
14 1 1461
2.9198

831

40.890
81.306
122196

167000
122196
648.04 for equalizing

40890 41.6116
1.15 0.0629
47.200 4.6745 with straight wire between the
minus 81.306 lbs.
128.506

187.000
128.506
585 00

2470
1701
1689
1991
1934
1683
1310
2620
1340
1280
480
455
69
204
40
479
352
205
469
1408
145
1410
23534
17366
40890

2590
2020
1150
426
970
277
116
542
935
390
655
971
287
100
100
30
241
73
60
1200
971
160
436
192
785
864
100
831
17366

1.1349
2.1671
2.2392
2.5412 3477.7

405 2.607 53
347.7 2.5412 45
1.165 .0663 18

Amount Cu to be multiplied by 1.165 to give amount wt straight wires

1000 feet out
2000 in total ~~gives~~ takes
125 lbs of Cu to
make one Ohm

10 lamps at equal distances along this will ~~take~~ have a fall of 5.24 Volts in 100 or 5.764 Volts in 110

1800 feet out will take 405 lbs. of Cu.
10 lamps along decreasing conductor will take
146.9 lbs and have 13.69 Volts fall

5.764 : 13.69 :: 146.9 : 347.7
347.7 lbs to have a fall of 5.764 Volts from 10 lamps along decreasing conductor 1000 feet long.

7.1 lbs both wires

3.55 each wire

1674
937
1602
914
1347
1694

0.55502
2.735 4
1.8148

65 wires

8228 feet 58 500 lbs

2

58.500 4.7672
8228 3.9151
7.1 lbs per foot 8521

No 10 lbs 94.6 1.9759
feet 1740 3.2405
2.7354

.0544 lbs per foot

Length of equalizing mains

29 30 556
137 492 600
34 39 157
137 188 199
36 42 70
89 156 20
61 10
264 937
44
328
54
110
64
20
188
40
39
1674

1602

2 285
142
10
35
234
26
249
20
155
35
108
974

2 998
247
1162
1162 536
184 602
546 10
157
32
546
1347

155
47
167
41
195
42
378
49
298
46
222
50
1694

To find point of greatest economy to run wires to

a = distance AB one station

b = BC

Lamps at C takes C^2 Cp of Cu

Lamps at b takes b^2

Let x = Bx where lamps is placed

then

$a^2 + 4x^2$ = Cu it takes supplied from A

$(a+b)^2 + 4(b-x)^2$ = Cu it takes supplied from C

$a^2 + 4x^2 \quad b^2 + 4(b-x)^2$

$b^2 + 4b^2 - 8bx + 4x^2$

$8bx = b^2 - a^2 + 4b^2$

$x = \frac{5b^2 - a^2}{8b}$

$a + b = 1267$

$a = 920$

$b = 347$

$2.9638 \quad b = 122000$

$5.9276 \quad a = 846000$

$122000 \quad 5$

610600

$347 \quad 8$

2776

85 feet

2,5403

2

5.0806

$2\,0000$

$2\,6000$

2788

2.3729

3.9452

1.9277

$a^2 + 4x^2 + b^2 + 4(b-x)^2$ must be a minimum

$8x + 8b + 8x = 0$

$b^2 - 2bx + x^2$

$16x = 8b$

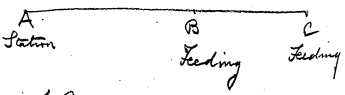
$x = \frac{1}{2}b$

$a^2 + 5x^2 + b^2 + 5(b-x^2)$

$10x^2 - 10b + 10x = 0$

$x = \frac{1}{2}b$

$a^2 + 4x^2 =$



$AB = a$
$AC = c$
$BC = b$

$a^2 + 4x^2 = c^2 + 4(6-x)^2$

$a^2 + 4x^2 = a^2 + 46^2 - 86x + 4x^2$

$86x = \frac{c^2 + 46^2 - a^2}{86}$

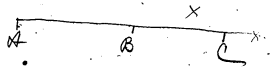
$x = \frac{c^2 + 46^2 - a^2}{86}$

$c = 1267 \quad c^2 = 1607000$
$a = 920 \quad a = 846000$
$6 = 347 \quad 6^2 = 122000$

4 1000000
1607000
488000
2095000
846
1249000

3.10028
2
6.2056
347
2716
6.0966
3.4435
2.6531

$x = 450$
397



$AB = a = 2$
$BC = b = 3$
$AC = c = 5$

$a^2 + 4x^2 = c^2 + 4(b - x^2)$

$a^2 + 4x^2 = c^2 + 4b^2 - 8bx + 4x^2$

$8bx = c^2 + 4b^2 - a^2$

$x = \frac{c^2 + 4b^2 - a^2}{8b}$

$\frac{25736 - 4}{24} = \frac{57}{24}$

1·7559
1·3802
·3757 2·3

$a = 9$
$b = 3$
$c = 12$

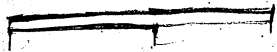
144
36
180
81
99

$x = \frac{99}{24} = 4\frac{1}{8}$

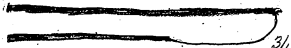
$a = 8$
$b = 3$
$c = 11$

121
36
157
64
93

24



If the cable runs between two points there will be a fall of E.M.F due to the line being



3/4

137
20
157
157
1299
1314.7

157
2
314

.052
3.2
104
156
166.1

520 lamps

1314.7
166.1
7.9

2.1185
2.2204
.9781

1/4 volts fall

2.5
125
375 volts fall

264
16
10
284
2
568

284
7.1
284
1988
20164

130
30
100
40
10
100
410

9.8

410
0
9.8
41
98
398
401.8

2 Volts fall
4.5 Volts

765
1267

16
49

49
7
343

18
78
1268

Problem.

1207

Day 100 lamps

752

What is the most economical point of division?

Day X feet from the 752 division

then 1000 − X from 1207

13
193
20
487
20
180
13
934.

1000
207
793

$\frac{X}{10}$ Campo supplied from 75-2 = 73 = 70.5 Ibs

$1 - \frac{X}{10}$ Campo from 1207 − 2414 = 182.

$\frac{X}{10} \times 70.5$ = Current main to 752

$\left(100 - \frac{X}{10}\right) 182$ Current summation to 1207

$\frac{.0002473 \, X^2 \, \frac{X}{10}}{10}$ = Current distributing from 752

$\frac{.0002473 \left(1000 - X\right)\left(100 - \frac{X}{10}\right)}{10}$ = Current distributing from 1207

$70.5 = 10 a^2$ $\quad .0002473 = 10\varepsilon$

$182 = 10 b^2$ $\quad \varepsilon = .0002473$

$\frac{X}{100} 70.5 + \left(10 - \frac{X}{100}\right) 182$

$+.00000\,2473\,X^3 + .000\,2473\left(1000 - X\right)^2\left(\frac{100 - X}{10}\right)$

$=$ min

$.705X + 1820 - 1.82X$

$1000000 - 2000X + X^2$

$1000000 - 2000X + 100X^2$

$1000000X + 200X^2 - \frac{X^3}{10}$

$1000000 - 3000000X + 3000X^2 - \frac{11X^3}{10}$

$24736 - 74.190000X + .07419X^2 - .00002473X^3$

$2473 - 7.419X + .007419X^2 - .00000247X^3$

$.000\,2473$

$\frac{3000000}{74.19000000}$

$.07419$

74.19
1.82
76.01
$.705$
75.305

7.419
1.82
9.239
$.705$
85.34

$( ) - 75.305X + .07419X^2 = \text{min}$

$\frac{2}{14838}$

$.14838X = 75.305$

1.8768
7.1712
2.7056

$.00002473$
$.00014838$
$.00014838$

$50 \text{ feet} = X$

$.014838X = 85.34$

$(1000 - X)^3$

$1000000000 - 3000000X + 3000X^2 - X^3$

$.00002473$

$.00002473$

2473
7.419

$.00002473$
2473
$.00007419$

Try $x = 300$

$1000 - x = 700$

3.0
70

6.3933
2.4771
2.4771
.4771
1.8346

211
683
2793

70.5
3
21 15 lbs.

182
7
1274 lbs.

6.3933
2.8451
2.8451
0.8451
2.7286

1274
848
2122

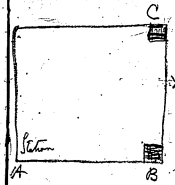
2122
2793
4915

$x = 700$
$1000 - x = 300$
3.
3.

211
848
1159

1159
1342
2501

1274
683
1342.3



$AC = a$

$AB = b$.

$CX = x$

$CB = c$

$BX = c - x$

Let $\mathcal{L}$ = Constant in means.

$\mathcal{E}$ = constant in distributing

$\mathcal{L}$ = Page 217

$\mathcal{E}$ =

n lamps

Lamps $\frac{x}{c}\,n$ towards C

$\frac{c-x}{c}\,n$ towards B

$\frac{x}{c} n a^2 \mathcal{F}$ = wk. main AC

$\frac{x}{c} n x^2 \mathcal{E}$ = wk. distrib. Cx

$\frac{c-x}{c} n b^2 \mathcal{F}$ = wk. main AB

$\frac{c-x}{c} n (c-x)^2 \mathcal{E}$ = wk. distributing Bx

$$\frac{x}{c} n a^2 \mathcal{F} + \frac{x}{c} n x^2 \mathcal{E} + \frac{c-x}{c} n b^2 \mathcal{F} + \frac{c-x}{c} n (c-x)^2 \mathcal{E} =$$

$$= \frac{n a^2 \mathcal{F}}{c} x + \frac{n \mathcal{E}}{c} x^3 + \left(n \mathcal{E} c^2\right) - \frac{n b^2 \mathcal{F}}{c} x$$

$$+ \frac{c^2 - 2cx + x^2}{c} (c-x) n \mathcal{E}$$

$$c^3 - 2c^2 x + cx^2 - c^2 x + 2cx^2 - x^3$$

$$\left(c^3 - 3c^2 x + 3cx^2 - x^3\right) \frac{n \mathcal{E}}{c}$$

$$+ \left(n \mathcal{E} c^2 - 3cn \mathcal{E} x + 3n \mathcal{E} x^2 - \frac{n \mathcal{E}}{c} x^3\right)$$

$\frac{\mathcal{F}}{\mathcal{E}}$ = 5.0969 / 4.6067 / 9.2218 / 8.9254 — decreasing

$\frac{\mathcal{F}}{\mathcal{E}}$ = 5.0969 −10 / 4.5403 / 9.2218 −10 / 8.8590 −10 — same sign

8.9254 / 8.8590 / .0664

log $\mathcal{F}$ = 5.0969 — decreasing
log $\mathcal{E}$ = 5.3933 — same sign
= 5.4597

$$(\ ) + \left(\frac{na^2\mathcal{F}}{c} - \frac{nb^2\mathcal{F}}{c} - 3cn\mathcal{E}\right)x + 3n\mathcal{E}x^2 = \text{min}$$

$$\partial_x \mathcal{E}x = \frac{nb^2\mathcal{F}}{c} + 3cn\mathcal{E} - \frac{na^2\mathcal{F}}{c}$$

$$X = \frac{b^2\mathcal{F}}{3c\mathcal{E}} + \frac{c}{2} - \frac{a^2\mathcal{F}}{6\mathcal{E}\mathcal{E}}$$

$$X = \frac{(b^2-a^2)\mathcal{F}}{6\mathcal{E}\mathcal{E}} + \frac{c}{2}$$

$$= \frac{(b-a)(b+a)\mathcal{F}}{6\mathcal{E}c} + \frac{c}{2}$$

10 lamps
200 feet main — 1.125
1 lamp 100 ohms — $\mathcal{F}$ = .0001125 — 10 Volts for 1 lamp
Decreasing — $\mathcal{E}$ = .00002473 — 2.5 Volts
Uniform Size = .00002882

$$\begin{array}{r} 5.9486 \\ 8.9254 \\ \hline 4.8740 \end{array}$$

$C = 9000$ 3.

1.8740 ⊗ 74.8

$C - X = 574.6$ feet

4.87402.

$C = 984$ 2.9930

1.8810

76

$$\begin{array}{r} 2\overline{)984} \\ 492 \\ \hline 76 \\ \hline 568 \end{array}$$

$C - X =$

$a = 754$

$b = 1207$

$C = 1000$

2.6561

3.2925

5.9486

5.0969

1.04555

9.171 5?

1.8740

3.7782

5.3933

9.171 5?

1207 − 754 = 453

1207 − 754 = 1961

$X = -74.8 + 500$

$C - X = 1000 + 74.8 - 500$

$C - X = 7\,6$

20
193
20
233

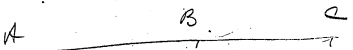
984.
233
751
568
183

C= 492
10
13
1
10
538

538
269

4.8740
538 2.7308
2.1432

140
269
409



~~$AB = a$~~ $\quad AC = a$

~~$BC = 1$~~ $\quad AB = x$

$BC = a - x$

$x^2 \mathcal{F} + (a-x)^2 \mathcal{E} = \text{minimum}$

$x^2 \mathcal{F} + a^2 \mathcal{E} - 2ax \mathcal{E} + x^2 \mathcal{E} = \text{minimum}$

$2a\mathcal{E} = 2(\mathcal{F}+\mathcal{E})x$

$x = \frac{2a\mathcal{E}}{\mathcal{F}+\mathcal{E}} = \frac{a \cdot \mathcal{E}}{\mathcal{F}+\mathcal{E}}$

~~$\mathcal{E}$~~ 247.3

247 $\quad$ 2.3927

372 $\quad$ 2.5705

8222

125
247
372

66.4. $\frac{2}{3}$ decreasing on duction

831
44
180
10
1065

452
10
1210
35
134
18
762

Same sige

288
125
413

288 2.4594
413 2.6160
.8434

69.7% of distance out is the place to put the distributing box

In Block 1

1207
30
80
10
286
20
198
644
2
1288

185
22
235
30
472
20
452
34
335
10
831

4.5289
2.5866
1.9423

87
193
280

324
28
10
20
386
193

a = 831

b = 472

c = 24
68
25
193
20
267
20
190.
25
162
30
10.20

a+b
831
472
1303

a-b
831
472
359

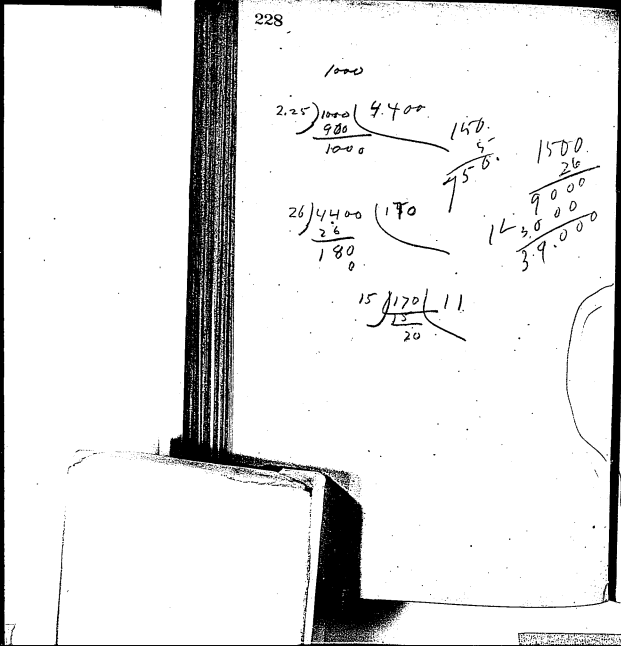
615
344
71
20

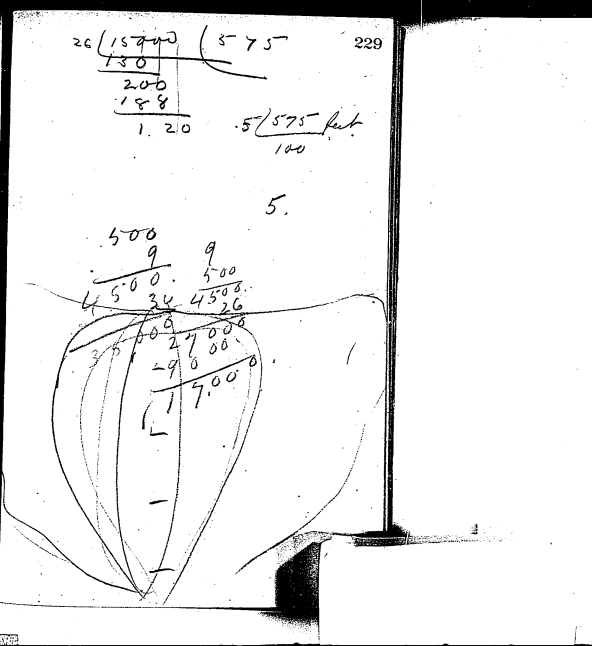
10 20
570

Same sign
1

2.5551
3.1148
8.8590
4.5289
3.0086
1.5203

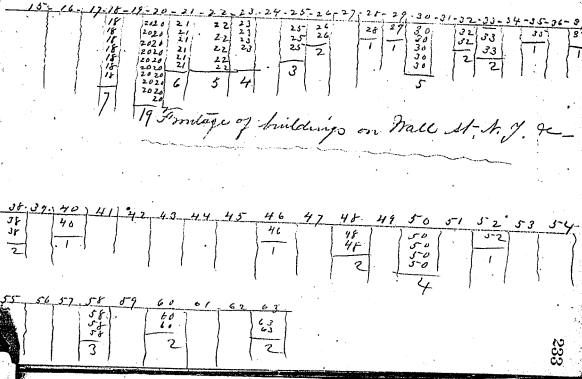
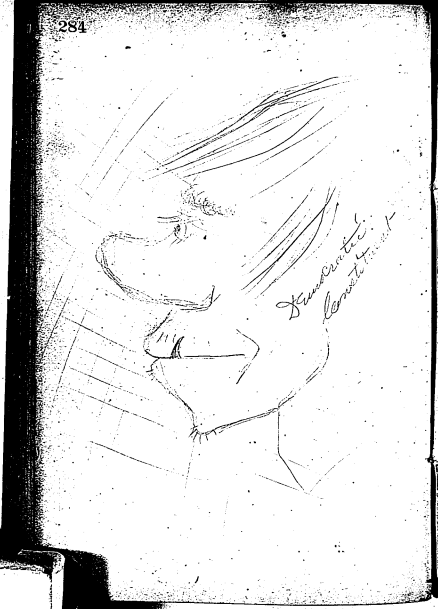
33.2
570
54.4





21-
20. along mullet
20.

33 - 20 - 22 -


15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
18
18
18